CODES AND STANDARDS ENHANCEMENT INITIATIVE (CASE)

Draft Measure Information Template – Residential Plug-load Controls

2013 California Building Energy Efficiency Standards

California Utilities Statewide Codes and Standards Team, August 2011

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2013 California Building Energy Efficiency Standards

California Investor Owned Utilities (IOU) Statewide Codes and Standards Team
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1. Purpose

Through Codes and Standards Enhancement (CASE) Studies, the California Investor Owned Utilities (IOUs) provide standards and code-setting bodies with the technical and cost-effectiveness information required to make informed judgments on proposed regulations for promising energy efficiency design practices and technologies.

The IOUs began evaluating potential code change proposals in the fall 2009. Throughout 2010 and early 2011, the CASE Team evaluated energy savings and costs associated with each code change proposal. The Team engaged industry stakeholders to solicit feedback on the code change proposals, energy savings analyses, and cost estimates. This Draft CASE Report presents the IOUs code change proposal for residential plug-load controls. The contents of this report, including cost and savings analyses and proposed code language, were developed taking feedback from industry and the California Energy Commission (CEC) into account.

The purpose of this measure is to reduce electrical energy wasted when residential appliances are not being used. Many electrical appliances draw power when in "sleep" mode or even when the power switch is turned off. Appliances that are only used for a few hours per day "leak" energy the rest of the time, sometimes due to power supplies or instant on features. This measure would cut the main power (mains) to a prescribed number of plug-in appliances on a regular schedule to achieve energy savings.

There are two ways that this measure can achieve savings. One is as a prescriptive measure, in the base or reach code. The other is as a compliance option, which will require the Residential ACM to be able to model plug loads and give some amount of credit for the installation of plug load controls. To develop the compliance option concept, further communication with stakeholders and software vendors will be needed.

This is a draft version of the CASE Report. A final version will be released in fall 2011.

2. Overview

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<table>
<tr><td>a. Measure Title</td><td>Residential Plug Load Controls.</td></tr>
<tr><td>b. Description</td><td>Many electronic appliances consume energy even when they are off. This measure provides an extra circuit that would enable residents to control the loss of energy due to appliance standby modes during periods of time throughout the day when no appliances on that circuit are being used.

This report investigates the feasibility and cost-effectiveness of requiring installation of an additional electrical circuit in all residential new construction dedicated to controlling the main household electric power (mains) to a number of wall receptacles (outlets) throughout the residence. The extra circuit would cover a total of 8 receptacles, and would be automatically controlled by a programmable Automatic Time Switch Control. The Automatic Time Switch Control would be set at the factory to shut the mains power off from midnight to 6 A.M., but the occupant can easily reprogram the settings. The controllable receptacles would be clearly marked and would not “crowd out” the standard distribution of receptacles. In other words, the regulations governing the distribution of standard receptacles would be unaffected by the extra controllable receptacles.</td></tr>
<tr><td>c. Type of Change</td><td>There are two potential code change paths discussed here. First, the proposed measure would appear as a prerequisite measure in Part 11 of Title 24, in the Residential Reach Code. This means it will not be required for all residential new construction throughout the state, but municipalities could choose to adopt it within their jurisdiction. Second, this CASE report proposes to include residential plug load controls as a compliance option in the residential ACM.</td></tr>
<tr><td>d. Energy Benefits</td><td>The proposed measure results in energy savings and demand reduction beyond 2008 Title 24 Code.

All yearly energy savings are multiplied against the 2013 TDV (Time Dependent Valuation) reach code values to determine the monetary value of the energy savings over the entire measure life cycle in the context of a reach code. The TDV values weight peak savings more heavily than off-peak savings to account for the real cost of energy to society. For residential measures, the TDV period of analysis is 30 years at a 3% discount rate.

<table>
<tr><th>Per Home</th><th>Electricity Savings (kwh/yr)</th><th>Demand Reduction (w)</th><th>Reach TDV Present Value Electricity Cost Savings</th></tr>
<tr><td>Aggressive Scenario</td><td>236</td><td>4.64</td><td>$876</td></tr>
<tr><td>Average Scenario</td><td>165</td><td>3.25</td><td>$608</td></tr>
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e. Non-Energy Benefits	Reducing electric energy consumption will reduce the use of the fuels that produce the electricity, resulting in a positive statewide impact on power plant emissions. Air quality will improve, reducing related illnesses, and improving community health in general.

f. Environmental Impact

To implement residential plug load controls additional wiring and electrical contactors may be required. Thus slightly more copper and plastic would be used in indoor wiring systems. The benefits of this measure are a reduction in the number of power plants needed, and a reduction in the size of the transmission and distribution system. The proposed change does not have any potential adverse environmental impacts, and all material uses are shown as No Change (NC).

Material Increase (I), Decrease (D), or No Change (NC): (All units are lbs/year)

	Mercury	Lead	Copper	Steel	Plastic	Others (Indentify)
Per Unit Measure[1]	N/A	N/A	N/A	N/A	N/A	N/A
Per Prototype Building	NC	NC	NC	NC	NC	N/A

Water Consumption:

	On-Site (Not at the Powerplant) Water Savings (or Increase) (Gallons/Year)
Per Unit Measure[1]	N/A
Per Prototype Building	NC

Water Quality Impacts:
There is not expected to be any change in water quality compared to a basecase assumption.

	Mineralization (calcium, boron, and salts	Algae or Bacterial Buildup	Corrosives as a Result of PH Change	Others
Impact (I, D, or NC)	NC	NC	NC	NC
Comment on reasons for your impact assessment				

g. Technology Measures	**Measure Availability:** The Automatic Time Switch Control is currently available from major lighting manufacturers such as Leviton, GE, Intermatic, and Honeywell. These products are available on the retail market. By and large, the features of the Automatic Time Switch Control required for this measure are already available from these manufacturers. Some minor adjustments may be required, such as setting a factory default of midnight to 6 A.M.. **Useful Life, Persistence, and Maintenance:** The Automatic Time Switch Control is expected to have a useful life of 15 years. No maintenance is required for the Automatic Time Switch Control, except possible replacement after 15 years. Energy savings are expected to persist for the entire life of the Automatic Time Switch Control. Verification is not expected to be necessary.
h. Performance Verification of the Proposed Measure	No additional performance verification such as diagnostic testing or acceptance tests will be required for compliance with this measure.

i. Cost Effectiveness

Demonstration of cost effectiveness is required for prescriptive measures. If considered as a prescriptive measure two scenarios are shown below to show cost effectiveness. The first scenario is the "aggressive" case. In this scenario, the home utilizes the controls for most of the appliances for which the controls are intended, and the controls are active from midnight to 6 A.M. every day and from 9 A.M. to 2 P.M. every weekday. The second scenario is the "average" savings case. This scenario is more conservative in terms of the portion of appliances that will be plugged into controllable receptacles, and the number of hours per day the controls will be utilized. Two tables are provided: one using Base Code TDV numbers and the other using Reach Code TDV numbers.

Demonstration of cost effectiveness is not required for compliance options.

Base code:

a	b	c	d	e	f	g
Residential Plug Load Control	Measure Life (Years)	Additional Costs[1]– Current Measure Costs (Relative to Basecase) ($)	Additional Cost Post-Adoption Measure Costs (Relative to Basecase) ($)	PV of Additional[3] Maintenance Costs (Savings) (Relative to Basecase) (PV$)	PV of[4] Energy Cost Savings (TDV) – Per Newly Constructed Residence (PV$)	LCC Per Prototype Building ($)
		Per Newly Constructed Residence	Per Newly Constructed Residence	Per Newly Constructed Residence		(c+e)-f Based on Current Costs
Aggressive Savings Scenario	30	$460	$460	$106	$695	-$129
Average Savings Scenario	30	$460	$460	$106	$483	$84

Reach code:

a	b	c	d	e	f	g
Residential Plug Load Control	Measure Life (Years)	Additional Costs[1]– Current Measure Costs (Relative to Basecase) ($)	Additional Cost Post-Adoption Measure Costs (Relative to Basecase) ($)	PV of Additional[3] Maintenance Costs (Savings) (Relative to Basecase) (PV$)	PV of[4] Energy Cost Savings(Reach TDV) – Per Newly Constructed Residence (PV$)	LCC Per Prototype Building ($)
		Per Newly Constructed Residence	Per Newly Constructed Residence	Per Newly Constructed Residence		(c+e)-f Based on Current Costs
Aggressive Savings Scenario	30	$460	$460	$106	$876	-$309
Average Savings Scenario	30	$460	$460	$106	$590	-$24

j. Analysis Tools	As a prescriptive measure in the reach code this proposal would not require the use of analysis tools because the measure is not subject to whole building trade-offs. If utilized as a compliance option in the base code, analysis tool would be incorporated into the Residential ACM to model plug loads and to give the appropriate credit for the installation of controls by reducing demand for certain plug loads during the time the plug load control is set to be in use based on required factory settings.
k. Relationship to Other Measures	This measure has some similarity to Nonresidential Demand Responsive Lighting Controls.

3. Methodology

3.1 Data Collection

The CASE team conducted a literature review pertaining to plug load energy usage, including standby and off mode “vampire” loads. Many studies have been published which explore various aspects of this problem, including the frequency of various plug loads in US residences, the duty cycles (ie percent of time spent in On, Standby, or Off modes), the typical power consumption in each of these modes, and the total impact of these plug loads on residential energy use. Some of the key findings from this literature review are provided here, and were used to develop energy savings calculations for this measure proposal.

The CASE team also conducted outreach to manufactures of timer based control products that serve as the basis for this measure. Information was gathered from these manufacturers about the capability of these products, the direction of the market, and the pricing of the products. The following manufacturers were contacted in 2010 and provided with a survey for information to be used in the development of this report. All responded except GE. The survey is included in the Appendix.

- Leviton
- General Electric
- Honeywell/Aube
- Intermatic

Internet research was also conducted to determine market prices for these controllers. Finally, RS Means was used as the basis for cost calculations for many of the measure components as well as the labor required to install them.

3.2 Measure Proposal

The residential electricity consumption in California in 2009 was 91,432 TWh[1]. Of that, 13% is reported to be “low power mode”, where an electric appliance is either in standby, or is off[2], corresponding to 112 watts per home. This means there is a fertile ground of over 10 TWh annually that can be targeted for energy conservation. A microwave oven typically uses more energy in 24-hour period for standby than it does for cooking. Trends over time show that the problem is getting worse, particularly with the increase in consumer electronics. In California, there has been a steady rise in the number of consumer electronic appliances purchased, which adds to the overall standby/off mode plug load energy use.

New construction is a good target for reducing residential plug load energy waste. Not all of the low-power energy use can be eliminated with circuit level controls, and not all homeowners will utilize

[1] Energy Consumption Data Management System website: http://ecdms.energy.ca.gov/elecbycounty.aspx.
[2] PIER CEC-500-2008-035 Low-Power Mode Energy Consumption in California Homes, Lawrence Berkeley National Laboratory, Sept. 2008.

circuit level controls even if they exist, but assuming 140,000 new housing starts per year in California[3], saving a mere 10% of the available 112 watts per home for 6 hours each day would amount to approximately 190 GWh of energy savings over a 10 year period.

Many home appliances including TVs, computers, plug-in battery rechargers, and stereo equipment are used for only a short time each day and some may not be used at all for many days at a time. Whether they are off, on or in standby mode many of these appliances draw some power for many hours each day during idle time, i.e., when they are not being used by anybody. If the mains power could be cut to these appliances during idle time a substantial amount of electrical energy could be saved. The proposed measure would require the installation of an additional electrical circuit in residential new construction that would be wired to a control device capable of turning off the mains power to the receptacles on that circuit. This will enable users to connect certain appliances (including electronics) to that circuit, to be sure they are not drawing power during times when they are not in use.

Mains power shut down and restoration time sequences can be programmable by the user, but the factory setting would be from midnight to six o'clock in the morning. Other power shut down schedules can be added, for example ten o'clock AM to one o'clock PM on weekdays. The circuit program can be manually overridden. For example, if the controller cuts the mains power to the circuit, the homeowner could manually override this to turn the power back on. Similarly, if the circuit program has the mains power on, the homeowner could manually override this and shut the power off. The programmable timer could be set to resume the schedule at the next transition (off-to-on or on-to-off), or it could be set to remain permanently off or permanently on until further user direction.

The programmable circuit would provide controllable receptacles in several rooms to accommodate various types of residential plug loads (e.g., computer equipment, home entertainment equipment, appliances, etc.).There is a need to be sensitive to equipment that cannot be turned off such as life support equipment. The receptacles on the programmable circuit would need to be well marked so that there is no confusion that the power is intended to be shut off at regularly scheduled intervals. Timers are readily available for programming a circuit like this, so there is no technical hurdle to installing a programmable circuit. In other words, this measure can be implemented now.

3.3 Energy Savings Methodology

Because plug loads are not part of residential building models, the CASE team developed an excel-based tool to model the power consumption properties for common home office and home entertainment appliances, along with the probability of finding each appliance in a typical California home. The calculations of frequency for the various appliances were based on several TIAX reports, which present the prevalence of appliances nationwide. It is assumed that the nationwide frequency is

[3] Get housing start ref from MM

a sufficient proxy for the frequency in California. For the special case of televisions California data from the Residential Energy Consumption Survey Data Tables[4] at was used.

This analysis assumes that the programmable circuits will be used most frequently overnight when the household members are asleep, though a significant portion of the population may also shut off power to selected appliances during the weekday when all the household members might be out of the house. Therefore, this analysis investigates the potential that savings will occur between midnight and six o'clock AM, representing the time many people are asleep, and between ten o'clock AM and one o'clock PM, representing the time many people are out of their houses at work or school. In this analysis these periods are referred to as the Programmed Off Interval.

The savings this measure can achieve depend on how much energy is being consumed on the circuit when the Programmed Off Interval is initiated. Devices generally draw more power when they are on than they do when they are off or in standby. We can assume that many appliances will be off during the Programmed Off Interval, and savings will be minimal. However, some of the devices that are expected to be plugged into the circuit, such as a modem, don't have an off switch, so they will be on when the Programmed Off Interval commences. The team used a scenario analysis to arrive at an estimate of the high range of expected savings per home and the statewide average savings per household (see Section 3.2.1 and 3.2.2 below).

Some of the appliances that are considered for this measure need to go through a shut down procedure before they can be unplugged (eg computers). These appliances should always be turned off before the mains power is shut off, so this study assumes that these devices will be in the Off mode when the Programmed Off Interval begins. However, these are still good candidates for controllable receptacles because they generally continue to draw some amount of power even when they are switched "Off".

On the other end of the spectrum are devices like the modem and wi-fi router, which generally don't even have an on/off switch, and as such are generally always in the On mode. They are not adversely impacted by a power shut down, and upon power being restored they go through an automatic set up lasting a minute or less. This analysis assumed that these appliances are always in the On mode when the Programmed Off Interval is initiated.

There is a third group of appliances that may be on or off at the time the mains power is cut. These include home entertainment appliances such as TVs and stereos. Unlike the first group, where the appliance should go through a shut down sequence, or the second group, where it is not expected that the appliance is ever switched off, this third group of appliances can be in the Off mode or the On mode when the Programmed Off Interval is initiated, without negative effects to the device. Table 1 shows the duty cycle for the targeted list of appliances. This will be a guide for the expected mode of an appliance when the Programmed Off Interval is initiated.

[4] Residential Energy Consumption Survey Data Tables. Website at: http://www.eia.gov/consumption/residential/data/2009/

Appliance	Appliance Duty Cycle (percent)		
	On Mode	**Standby Mode**	**Off Mode**
Personal computer	33.0%	4.0%	63.0%
Monitor	21.0%	10.0%	69.0%
Notebook computer	27.0%	11.0%	62.0%
DSL modem	100%	0%	0%
Cable modem	100%	0%	0%
Wi-fi router	100%	0%	0%
Multi-function device, inkjet	3.0%	7.5%	89.5%
Printer, inkjet	1.5%	0%	98.5%
Set top box, cable	31.0%	0%	69.0%
Set top box, satellite	37.0%	0%	63.0%
Personal video recorder	24.0%	0%	76.0%
Cordless phone	4.0%	8.0%	88.0%
Video game systems	4.6%	6.4%	89.0%
Home theater in a box	18.0%	8.0%	74.0%
Compact stereo	9.5%	8.0%	82.5%
Component / rack stereo	18.0%	8.0%	74.0%
DVD player	3.0%	10.0%	87.0%
TV	22.0%	0%	78.0%
Radio	5.0%	0%	95.0%
Power speakers	8.0%	23.0%	69.0%
Portable stereo	6.0%	13.0%	81.0%

Table 1. Duty Cycle of Appliances in Targeted list[5].

A number of appliances do not recover well from a six hour power shut down, such as VCRs, clock radios, etc., in that they need to go through some kind of manual set up after power is restored. Even though there is a significant amount of energy to be saved by finding a way to shut them down, this study did not consider them as candidates for controllable receptacles, and they are not targeted for this measure.

[5] Energy Consumption by Consumer Electronics in U.S. Residences. Kurt W. Roth, Kurtis McKenney. TIAX Reference - D5525. January, 2007.

3.3.1 Aggressive Savings Scenario

The "aggressive" scenario represents the savings expected to be achieved by a household that takes advantage of the presence of the circuit and controller by maintaining a scheduled Programmed Off Interval during the night (midnight to 6AM) and during the middle of the day (10AM – 1PM).

The aggressive scenario also assumes the home contains all of the appliances that are estimated to exist in more than 20% of California homes. As a result, the full standby or off power draw of those appliances was captured in the calculation of savings. For example, notebook computers are estimated to be present in 34% of homes, so the full standby and off power consumption of the notebook computer was considered in the savings analysis conducted for the aggressive scenario. There is an estimated 2.3 TVs per household. For the sake of the aggressive scenario this was rounded up to 3.0.

However, the analysis also considered whether certain appliances are generally mutually exclusive in a typical home. For example, if a cable modem is assumed to be present in a home, it is assumed that a DSL modem is not present. Similarly, if a multifunction device (all in one printer, copier and fax) is present, then a stand-alone printer is assumed not to be present. For these types of mutually exclusive appliances, the analysis assumed the existence of the device with the greater saturation in U.S. homes.

3.3.2 Average Savings Scenario

The “average” scenario serves as an estimate of more typical savings resulting from this measure on a per household basis. In this scenario the power draw of each appliance was multiplied by the percentage of California homes in which the appliance can be found. For example, if notebook computers are found in 34% of homes and the power draw from a notebook computer in off mode is 2 watts, the reported power savings for the average scenario would be 2 watts times 34%, or 0.68 watts. This scenario essentially represents the per home statewide average for new residential construction, and it was used as a proxy for determining cost effectiveness for the average home.

In the average savings scenario, savings were assumed to consistently occur between midnight and 6AM, based on the factory-shipped settings required by the control device. Savings were also assumed to occur between 10 AM and 1 PM.

Armed with these assumptions the methodology for determining savings was straightforward. Table 4 provides the power draw for each appliance operating in the on, off, and standby modes. After the CASE Team determined which mode each appliance should be in during the Programmed Off Interval, the power draw for that interval was summed across the appliances for the total power that can be saved.

3.4 Cost Methodology

The equipment and installation costs were estimated using RS Means[6] cost data and information from programmable timer manufacturers, as shown in Table 2. The CASE team conducted outreach to four controls manufacturers throughout 2010 to determine the current capability and prices of products on

[6] RS Means 2010. Costworks. *2010 4th Quarter Data*. http://www.meanscostworks.com/

the market. Manufacturer surveys were conducted to assess the feasibility of changes that would be needed for these products to be compliant with this code proposal.

The Automatic Time Switch Control considered as most applicable for this analysis is the Leviton VPT-24 lighting controller, shown in Figure 1. This controller retails for $46.49 on Amazon.com. This analysis used a conservative wholesale cost of $30.00, based on confidential data provided by manufacturers. In addition, it is assumed that the Automatic Time Switch Control will be replaced after 15 years. The present value for that replacement is included.

RS Means data includes material costs and labor costs combined. Essentially the Automatic Time Switch Control is a modified light switch and it fits in a light switch receptacle. The labor associated with installing a light switch is the most applicable information to use. The combination of material cost and labor cost in RS Means for installing a light switch is $45.00 on line number 260590.102110. This represents $10.05 for the material and $34.95 for the labor. But in this case a $10.05 light switch is not being installed. A Automatic Time Switch Control is being installed with labor cost $34.95. Using an estimated wholesale cost of $30.00 for the Automatic Time Switch Control we can provide an estimated cost for material and labor of $64.95 for installation.

Components	**Qty**	**Unit Cost**	**Extended Cost**	**RSMeans[4] line number**
Automatic Time Switch Control	1	$64.95	$64.95	#260590.102110
Breaker	1	$76.00	$76.00	#262416.200100
Receptacle	6	$49.50	$297.00	#260590.104015
Replacement Automatic Time Switch Control	1	101.189984	$101.19	(Replace controller after 15 years)
			$539.14	total cost
			1.05	CA multiplier *
			$566.27	measure cost

Table 2. Total Measure Cost

* Thirty-seven California cities are listed in the Location Factor section of RS Means. Taking a rough population weighted average the multiplier for California should be about 1.05 (see Appendix).

Figure 1. Leviton VPT-24

3.5 Cost Effectiveness Methodology

The CASE Team used California Energy Commission’s Life Cycle Costing (LCC) methodology to calculate the cost effectiveness of the proposed measure.

4. Analysis and Results

4.1 Appliance Frequency

Table 3 lists the common computer and home entertainment appliances targeted in this study, showing their frequency within the US household. It is expected that many more appliances in these categories exist in the average Californian home than the ones listed. This is considered a conservative sample. Table 4 shows the same list of appliances with their power consumption by mode (on, off, standby).

Appliance List	Frequency in US households (%) (115 M 2006)	Source Document
Personal computer	78.0%	TIAX D5525[5]
Monitor	78.0%	TIAX D5525
Notebook computer	34.0%	TIAX D5525
DSL modem	20.0%	TIAX D0370[7]
Cable modem	20.0%	TIAX D0370
Wi-fi router	40.0%	sum of modems
Multi-function device, inkjet	45.0%	TIAX D0370
Printer, inkjet	45.0%	TIAX D0370
Set top box, cable	67.0%	TIAX D5525
Set top box, satellite	61.0%	TIAX D5525
Personal video recorder	1.7%	TIAX D5525
Cordless phone	108.0%	TIAX D5525
Video game systems	55.0%	TIAX D5525
Home theater in a box	22.0%	TIAX D5525
Compact stereo	66.0%	TIAX D5525
Component / rack stereo	45.0%	TIAX D0370
DVD player	104.0%	TIAX D5525
TV	230.0%	RECS at US EIA[8]
Radio	49.0%	Building America report[9]
Power speakers	29.6%	Building America report
Portable stereo	34.8%	Building America report

Table 3. List of Appliances with Frequency in US households.

[7] Residential Miscellaneous Electric Loads: Energy Consumption Characterization and Savings Potential. . Kurt W. Roth, Kurtis McKenney. TIAX Reference – D.370. July, 2007.

[8] RECS at US EIA is located at http://www.eia.gov/consumption/residential/data/2009/. RECS is Residential Energy Consumption Survey at the U.S. Energy Information Administration.

[9] Building America - Resources for Energy Efficient Homes located at http://www1.eere.energy.gov/buildings/building_america/analysis_spreadsheets.html.

Appliance List	Power Consumption by Mode (W) "on" mode	"sleep/standby" mode	"off" mode	Power Consumption Source Document
Personal computer	75	4	2	TIAX D5525
Monitor	42	1	1	TIAX D5525
Notebook computer	25	2	2	TIAX D5525
DSL modem	5.37	0	1.37	LBNL report[10]
Cable modem	6.25	3.85	3.84	LBNL report
Wi-fi router	5.37	0	1.37	unconfirmed
Multi-function device, inkjet	15.2	9.1	6.2	Building America report
Printer, inkjet	4.9	0	1.7	Building America report
Set top box, cable	16	0	15	TIAX D5525
Set top box, satellite	15	0	14	TIAX D5525
Personal video recorder	27	0	27	TIAX D5525
Cordless phone	4.2	3.4	2.5	Building America report
Video game systems	36	36	1	TIAX D5525
Home theater in a box	38	34	0.6	TIAX D5525
Compact stereo	23	16	7	TIAX D5525
Component / rack stereo	45	43	3	Building America report
DVD player	14	11	2.9	TIAX D5525
TV	192	0	4	Building America report
Radio	2	0	1	Building America report
Power speakers	6	4	2	Building America report
Portable stereo	6	5	1.8	Building America report

Table 4. Power Consumption by Mode (On, Off, Standby).

4.2 Demand Reduction

Table 5 shows the power reduction achieved in the "aggressive" scenario and in the statewide "average" scenario. The aggressive savings scenario results in a reduction of 80.14 watts per household and the statewide average scenario results in a reduction of 56.06 watts per household during the Programmed Off Interval. It is assumed that these savings will occur between midnight and

[10] Lawrence Berkeley National Laboratory: Standby Power Summary Table. This is a table of appliances with power draw as a function of mode located at http://standby.lbl.gov/summary-table.html.

6:00 AM daily, and from 10:00 AM to 1:00 PM on weekdays only for both the aggressive and average scenario.

Appliance	Aggressive Scenario (W)	Statewide Average Usage Scenario (W)
Personal computer	2	1.56
Monitor	1	0.78
Notebook computer	2	0.68
DSL modem	Not used	1.07
Cable modem	6.25	1.25
Wi-fi router	5.37	2.15
Multi-function device, inkjet	6.2	2.37
Printer, inkjet	Not used	0.57
Set Top Box, cable	Not used	10.0
Set Top Box, satellite	14	8.54
Personal video recorder	Not used	0.46
Cordless phone	3.0	3.22
Video game systems	4.5	1.4
Home theater in a box	3.9	0.87
Compact stereo	7.0	4.62
Component / rack stereo	7.0	3.01
DVD player	2.9	3.02
TV	12	9.2
Radio	1	0.49
Power speakers	2	0.59
Portable stereo	Not used	0.63
TOTAL Power Savings	**80.14**	**56.06**

Table 5. Power reduction by aggressive user and statewide average user.

Note: The Automatic Time Switch Control draws 0.2 watts for 24 hours per day and offsets the savings by that amount.

4.3 Energy Cost Savings

Energy cost savings estimates were developed using the CEC-developed TDV methodology, which calculates the total present value energy cost savings over a 30 year period of analysis. The energy cost savings are summarized in Table 6.

4.3.1 Base Code TDV, Aggressive Scenario

The expected hourly demand reduction values in the aggressive scenario were multiplied by the base code TDV values ($/watt*hour) used for evaluating the cost effectiveness of proposed code changes to be incorporated into Part 6 of Title 24. Assuming that savings would occur 365 days a year between midnight and 6:00 AM, and on weekdays between 10AM and 1PM, the energy cost savings would be $695.50.

4.3.2 Reach Code TDV, Aggressive Scenario

The expected hourly demand reduction values in the aggressive scenario were multiplied by the reach TDV values ($/watt*hour) used for evaluating the cost effectiveness of proposed code changes to be incorporated in to Part 11 of Title 24. Assuming that savings occurred 365 days in the year between midnight to 6:00 AM, and on weekdays between 10AM and 1PM, the energy cost savings would be $875.63.

4.3.3 Reach Code TDV, Average Scenario

The expected hourly energy savings from the statewide average scenario were multiplied by the reach TDV values ($/watt*hour) used for evaluating the cost effectiveness of proposed code changes to be incorporated in to Part 11 of Title 24. Assuming that savings occurred 365 days in the year between midnight to 6:00 AM, and on weekdays between 10AM and 1PM, the energy cost savings would be $607.75.

PV Electricity Cost Savings	**Aggressive Scenario**	**Average Scenario**
Base TDV 30 year savings for midnight to 6 am daily	$470.89	$327.50
Base TDV 30 year savings for 10 am to 1 pm weekdays	$224.61	$155.22
Total Base 30 year savings: overnight and 3 hrs weekdays	**$695.50**	**$482.72**
Reach TDV 30 year savings for midnight to 6 am daily	$592.85	$412.33
Reach TDV 30 year savings for 10 am to 1 pm weekdays	$282.78	$195.42
Total Reach 30 year savings: overnight and 3 hrs weekdays	**$875.63**	**$607.75**

Table 6. Total Cost Savings.

4.4 Measure Cost

The measure cost is shown in Table 7. It is assumed that the controller will need to be replaced after 15 years of service.

Components	qty	Unit Cost	Extended Cost	RS Means[4] line number
Automatic Time Switch Control*	1	$64.95	$64.95	#260590.102110 *
Breaker	1	$76.00	$76.00	#262416.200100
Receptacle	6	$49.50	$297.00	#260590.104015
Replacement Automatic Time Switch Control	1	$101.19	$101.19	(Replace controller after 15 years)
			$539.14	total cost (US average)
			1.05	CA multiplier **
			$566.27	Total cost in California

Notes:

$30.00 estimated wholesale cost of timer/controller. The retail cost is $46.49 (Amazon.com)

* The cost for this line number is $45 in the RS Means book[6]. The material cost of the switch $10.05 was subtracted off. The estimated wholesale cost of the Leviton VPT-24 controller $30 was added on.

** Thirty-seven California cities are listed in the Location Factor section of RS Means. Taking a rough population weighted average the multiplier for California should be about 1.05 (see below).

Table 7. Cost of installed system components (includes material cost, labor, overhead and profit, adjusted for California). Taken from 2010 RS Means Electrical Cost Data.

4.5 Base Code Life Cycle Cost

As shown in Table 8, when conducting the life cycle cost analysis required for all base code measures (i.e., using Base Code TDV developed by CEC), the "aggressive" savings scenario is cost effective over the measure life, but the "average" savings scenario is not. These two saving scenarios are defined in Section 4.3.

a	b	c	d	e	f	g
Residential Plug Load Control	Measure Life (Years)	Additional Costs[1]– Current Measure Costs (Relative to Basecase) ($)	Additional Cost Post-Adoption Measure Costs (Relative to Basecase) ($)	PV of Additional[3] Maintenance Costs (Savings) (Relative to Basecase) (PV$)	PV of[4] Energy Cost Savings(Base TDV) – Per Newly Constructed Residence (PV$)	LCC Per Prototype Building ($)
		Per Newly Constructed Residence	Per Newly Constructed Residence	Per Newly Constructed Residence		(c+e)-f Based on Current Costs
Aggressive Savings Scenario	30	$460	$460	$106	$695	-$129
Average Savings Scenario	30	$460	$460	$106	$469	$97

Table 8. Base Code Life Cycle Cost

4.6 Reach Code Life Cycle Cost

As shown in Table 9, when conducting the life cycle cost analysis required for all base code measures (i.e., using Reach Code TDV developed by CEC), both the “aggressive” savings scenario and the “average” savings scenario are cost effective over the measure life. These two saving scenarios are defined in Section 4.3.

a	b	c	d	e	f	g
Residential Plug Load Control	Measure Life (Years)	Additional Costs[1]– Current Measure Costs (Relative to Basecase) ($)	Additional Cost Post-Adoption Measure Costs (Relative to Basecase) ($)	PV of Additional[3] Maintenance Costs (Savings) (Relative to Basecase) (PV$)	PV of[4] Energy Cost Savings(Reach TDV) – Per Newly Constructed Residence (PV$)	LCC Per Prototype Building ($)
		Per Newly Constructed Residence	Per Newly Constructed Residence	Per Newly Constructed Residence		(c+e)-f Based on Current Costs
Aggressive Savings Scenario	30	$460	$460	$106	$876	-$309
Average Savings Scenario	30	$460	$460	$106	$590	-$24

Table 9. Reach Code Life Cycle Cost

5. Recommended Language for the Standards Document, ACM Manuals, and the Reference Appendices

5.1 Prerequisite Part 11 Code Language

The following is a draft of the proposed code language as a prerequisite measure, to be included in Part 11 of Title 24:

In all residential new construction and major renovations, permanently installed controlled receptacles shall be provided that will automatically shut off electricity to task lighting and plug loads via time schedule or occupancy status of the room. These receptacles shall be automatically controlled through a dedicated circuit, through communication of control signal to controlled receptacles, through on-board automated control of receptacles, or through another method of providing scheduling control or occupancy control of the receptacles.

Control can either be achieved with an automatic time switch control, or by an occupant sensing device, as defined in Title 20, section 1602 (j). The controlled receptacles shall be able to be turned on or off manually.

If an occupancy sensor is used, manual on shall be required to restore power to the circuit. If an automatic time switch is used, restoration of power to the circuit can either be manual or automatic.

Controlled receptacles shall meet the following requirements:

1. If an automatic time switch control is used, it shall conform to Title 20 section 1605.3 (j)(2), except as regards override. There will be two override capabilities. The first override duration will extend to the next program change. The second override function will allow the automatic time switch control to be set permanently on or permanently off. The automatic time switch control shall be readily accessible, and there shall be capability for at least two on-off programs per day during the week and at least one on-off program per day on the weekend.
2. If an occupancy control is used, the occupant shall be able to set it to a permanently on or permanently off state.
3. There shall be at least four permanently installed controlled receptacles in three separate locations within the house: the master bedroom, living room/family room, and home office or bedroom capable of serving as a home office. A receptacle is defined in Article 100 of Title 24. A controlled receptacle may be ganged with an uncontrolled receptacle on the same duplex yoke, but the controlled receptacle must be clearly marked as described below.
4. Controlled receptacles shall have a permanent marking to differentiate them from uncontrolled receptacles, where the marking is visible after installation, and makes explicit the intermittent power connectivity of the receptacle. This is to help prevent accidents caused by certain plug loads when an automatically off receptacle is automatically switched back on.
5. Controlled receptacles shall be additional to those uncontrolled receptacles already required under Title 24.

5.2 Compliance Option in Part 6

This CASE report also proposes changes to the Residential ACM for this measure to be considered as a compliance option. The Residential ACM will need to be developed to model typical plug load use, and to give credit to residential buildings with plug load controls installed. Additional development work will need to be completed, and this CASE report recommends further coordination with software developers. This report provides average standby plug load wattage of typical electronics along with their prevalence in U.S. homes. This can serve as the basis for a model of typical plug load demand. Any model should be designed to give credit for reduced standby load wattage during the hours of midnight to 6A.M., which are the recommended hours for the factory pre-settings for the plug load controls.

6. Bibliography and Other Research

1. Energy Consumption Data Management System website: http://ecdms.energy.ca.gov/elecbycounty.aspx. Sum over all California counties. 2009 data.

2. PIER CEC-500-2008-035 Low-Power Mode Energy Consumption in California Homes, Lawrence Berkeley National Laboratory, Sept. 2008.

3. Housing starts reference.

4. Residential Energy Consumption Survey Data Tables. Website at: http://www.eia.gov/consumption/residential/data/2009/

5. Energy Consumption by Consumer Electronics in U.S. Residences. Kurt W. Roth, Kurtis McKenney. TIAX Reference - D5525. January, 2007.

6. RS Means 2010. Costworks. *2010 4th Quarter Data*. http://www.meanscostworks.com/

7. Residential Miscellaneous Electric Loads: Energy Consumption Characterization and Savings Potential. . Kurt W. Roth, Kurtis McKenney. TIAX Reference – D.370. July, 2007.

8. RECS at US EIA is located at http://www.eia.gov/consumption/residential/data/2009/. RECS is Residential Energy Consumption Survey at the U.S. Energy Information Administration.

9. Building America - Resources for Energy Efficient Homes located at http://www1.eere.energy.gov/buildings/building_america/analysis_spreadsheets.html.

10. Lawrence Berkeley National Laboratory: Standby Power Summary Table. This is a table of appliances with power draw as a function of mode located at http://standby.lbl.gov/summary-table.html.

11. Ross, J. P. and Meier, Alan, "Whole House Measurements of Standby Power Consumption" Proceedings of The Second International Conference on Energy Efficiency in Household Appliances, Naples, September 2000.

7. Appendices

RS Means supplies estimates for material and labor construction costs. They are considered the national average costs. Those base costs can be multiplied by "Location Factors" that account for local differences in costs around the country, where 100 represents the national average that is reported in the book. There are 37 metropolitan areas for California covered by RS Means. The location factor is essentially a percentage. If the cost of "X" is $45.00, and the location factor for a specific municipality is 110, then the cost of "X" in that municipality is $45.00 x 110% = $49.50. To get a representative location factor for the whole state a population weighted average was calculated on the assumption that population is a proxy for new construction from region to region. Table 10 shows the calculations used to determine a statewide average of Location Factor. It is assumed there are 37 million people in California. Locations and corresponding populations with Location Factor greater than 100 are listed in Table 10. This group of locations account for 17.96 million of the 37 million people in California. The product of the location factor and the population is shown in the far right column of Table 11. Then the formula for determining the statewide Location Factor becomes (100(37-17.96) + 1982.22)/37 = 1.05.

RS Means Location Factor above national average (100)	Location	Approximate Population (million)	Product of Location Factor times population
123	San Francisco County	0.8	98.4
113	Santa Clara County	1.7	192.1
114	San Mateo County	0.7	79.8
110	Solano County	0.3	33
114	Alameda County	1.4	159.6
113	Contra Costa County	1	113
114	Marin County	0.25	28.5
110	Santa Cruz County	0.25	27.5
112	Sonoma County	0.46	51.52
108	Los Angeles	9.9	1069.2
108	Sacramento County	1.2	129.6
	sums	17.96	1982.22

Table 10. Determination of RS Means Location Factor for California.

Blank Survey for Automatic Time Switch Control Manufacturer.

Recommended model number:

Cost:

1. Can this controller switch a 15 amp hardwired circuit? If not, is there a model number that can?

2. How many events can it program? For example, are there separate programs or schedules for weekday vs. weekend? More than one schedule or cycle per day?

3. Current features. Is there a manual override? Specifically, if a program has the mains power off, is it simple to cycle the power on? Is it simple to put the controller back on schedule? Does the program catch up & resume control after manual override? Is it possible to lock the controller in the off mode (e.g., for a 2 week vacation)?

4. Is this product compatible with plug load control (vs. lighting only)? Does it use a triac for switching?

5. What is the power draw of this controller in the Off mode? On mode? Are there ways to reduce the power draw?

6. Failure mode and warranty: What is the expected life of this controller? What maintenance is necessary? What happens when the battery fails? Is this product set up for a battery change? Does the switch fail to On, or does the circuit shut down?

7. Cost reduction: Can astronomical feature and/or random setting feature be removed? Any cost reduction for plug load control?

8. Feature changes: Can permanent override to ON be disabled? Can there be a factory preset where controller is programmed to be off midnight to 6 am, and on the rest of the time?

9. Pricing: Suggested retail price for annual volume of 20k, 50k, 100k.

10. Energy efficiency. Have you investigated using this controller for energy efficiency applications? Do you know of any studies on this topic?

11. Would it be possible to get a sample?